Teaching Laboratories Roundtable
Summary

Background

As part of the Laboratories for the 21st Century (Labs21) conference, a Teaching Laboratory Roundtable was held on January 9, 2002, from 4:30 to 6:00 pm. The purpose of the Roundtable was to bring together a diverse group of teaching laboratory professionals (professors, managers, builders, and designers) from the college and university setting for a focused discussion on the issues and challenges faced in improving laboratory energy and environmental performance. The following list of issues was identified and developed by a workgroup representing the teaching laboratory in an effort to identify key issues faced in creating laboratories for the 21st century and served as the basis for the topics discussed at the Roundtable. *Each section includes notes from the discussion that took place at the Roundtable in January.*

Overview. The Building Process as a Training Tool (Planning a Learning Lab)
(Presentation given by Jim Jones, Virginia Technology Institute. See PowerPoint Presentation for more details.)

Opportunities abound to use a safe, healthy, and resource efficient laboratory as a training tool. From programming through construction, a collaborative design team can use the charrette process to learn from each other and the community in the broadest sense of the term. Creative solutions to complex challenges often are found through collaborative activities.

Balancing conflicting needs is the inevitable challenge. Teaching laboratories often double as research centers or vie for the same resources. Early planning for maximum flexibility through modularity is but one opportunity to extend the building's life. Attitudes and expectations of first cost can be broadened with the understanding and adoption of life cycle costing.

Product selection offers opportunities to educate consumers across the spectrum. Construction projects are vehicles for sharing information and processes in product decision-making. Educational institutions are uniquely positioned to undertake life cycle analysis projects that will impact our understanding of the holistic approach to the built environment.

An increase in cost for a collaborative design process should be anticipated; however, a balance and often a savings comes in efficiency gains during construction and long-term operations and maintenance. National studies are underway using LEED™ certified buildings as a database for a diversity of research projects.

Beyond construction, a sustainable building is an ideal tool for education of occupants as well as visitors. Case studies of buildings that teach, like most of the LEED™ certified buildings, show expenditures from small to major investments depending upon the commitment of owner and users to the goal of "green" education.

Issue #1. Environmental Health & Safety (EHS) Participation in the Design and Upfit of Teaching Laboratories

(Presentation given by David Rainer, North Carolina State University. See PowerPoint presentation for additional information.)

Discussion:

A major issue in university laboratory design is the lack of EHS staff involvement. Often EHS personnel are excluded, intentionally or accidentally, from the formal design and construction process in universities. Architects and consultants often don't solicit EHS feedback, aren't asked to speak with EHS staff, or don't incorporate their input. By the same token, designers hired by a university typically only deal with individual departments or stakeholders, and as a result, don't see the full scope of people they need to work with. Many universities do not push for EHS involvement because as long as the building can pass code compliance, it is satisfied.

Sometimes a university will bring on an EHS consultant to interpret an architectural design for compliance. The problem here is that many EHS staff are not trained to understand architectural designs. One possible solution is a systemized method of getting everyone involved in lab design from the beginning of the project – creating a holistic, inclusive discussion.

Environmental health and safety-related problems usually arise on smaller projects. Larger projects often involve broader participation, including EHS officials.

Issue #2. Heat Recovery

(Presentation given by Marty Altschul, Carnegie Mellon University)

Laboratory fume hoods exhaust large volumes of air, making them candidates for heat recovery. Virtually all heat recovery systems can be broken down into the following classifications:

- Fluid run-around systems
- Heat/Energy Wheels
- Heat Pipe systems.
- Air-to-Air Heat Exchangers
- Liquid spray systems

Each of these systems has its own strengths and weaknesses. Several questions need to be answered when evaluating the use of a heat recovery system. Among these are:

- Does the heat recovery system have the potential to carry potentially harmful materials back into the laboratory?
- System maintenance: Will the heat recovery system add complexity to the system to the point of being difficult to operate and/or maintain, increasing both maintenance costs and risk to the occupants?
- If the system requires exhaust and intake air streams to be in close proximity, how will re-entrainment of exhaust gases be avoided?
- How will workers maintaining the heat recovery system be protected from exposure to potentially harmful concentrations of the materials being exhausted?

- Will the heat recovery system slow the exhaust stream to the point that solid particles may drop out?
- Does the heat recovery system increase the potential for concentrating or mixing chemicals in a way that may increase hazards (cross contamination)? Level of hazard is less for teaching labs than research labs.
- How are the chemicals being stored (in fume hoods, in the lab, or in separate storage space)? This can affect whether or not you can shut down the exhaust system.
- The greatest benefits from total recovery systems are seen in Virginia and to the south.
- Given these and other factors, will the heat recovery system provide an acceptable overall cost/benefit analysis?

Designers and owners need to consider some of these questions on every laboratory exhaust job. Others apply to heat recovery systems in general while some are unique to particular types of heat recovery systems. Every situation is different and needs to be evaluated carefully.

Discussion:

There is the potential to be more aggressive in heat recovery for teaching labs because:

1. While there is a high quantity of fume hoods, there is low diversity. The use of fume hoods are also more scheduled than other research labs.
2. The chemicals used in teaching labs are generally known and less hazardous than in research facilities.
3. The risk in teaching labs comes from the students' learning curve. They are generally unfamiliar with proper lab systems and procedures, and can make honest, naive mistakes.

Issue #3. Diversity Factors
(Presentation given by Karl Brown, University of California-Merced)

Diversity factors are important with respect to both heat loads and fume hood air systems.

Heat Loads:
For heat loads, the typical design process confuses three distinctly different quantifications of load: the sum of nameplate ratings, the sum of actual maximum loads for all equipment, and the actual maximum load that will ever be observed. The difference between nameplate ratings and actual maximum loads for equipment can be as high as a factor of five due to the sizing of power supplies. The difference between the sum of all maximum loads for all equipment and the actual maximum load that will ever be observed is the diversity factor. Diversity factors of 50% or less are common. Accurate estimates of diversity factors can mean the difference between air systems and cooling plant that do not operate properly because they are not loaded up to a stable operating condition, and systems that operate efficiently under most operating conditions.

Design process:
Similarly, the typical design process does not adequately assess the diversity in hood operation. It is often assumed that teaching labs will have all hood sashes fully open as a whole class does the same procedures. And that all labs in the building work on the same schedule. Thus, current design/system selections are made based on 10 watts/square foot.

Evaluations have shown that this scenario is basically never seen. Instead, system selections are often completely wrong for the building, and loads are much less than 10 watts/square foot. This is due to incorrect assumptions of use. In reality, teaching assistants often do much of experiment set-ups, proper hood practice dictates that sashes are open only intermittently during experiments, and many experiments do not directly use hoods at all. Air systems must be able to operate efficiently in the most proper scenario–most sashes closed.

Discussion:

When designing buildings for universities, one has to keep in mind that:

- Their use may change over time, especially given the fact that many of these buildings last hundreds of years.
- Teaching labs are often mixed-use space.
- How the sciences are taught should influence how the building is designed.
- Disposal of chemicals in teaching labs can influence cost.

A major problem in deciding diversity factors is the issue of risk. How a system is designed can become a liability issue even if it is not a code issue. Put simply, the more risks that are taken the greater the payback. Conversely, to build a research or teaching lab that is safe, one might need to spend more money and lose some energy efficiency. The question, therefore, is who should decide the diversity factor versus the risk factor, and how to balance the two? Universities are somewhat unique in this realm in that most have staff to do risk assessments and make decisions based on those assessments.

In general, universities are willing to take a greater risk in relation to chillers because the worst that can happen is the room gets a little warm. They are less willing to deal with risk when it comes to issues such as hood diversity because the consequences are more severe if something goes wrong.

One of the goals of Labs21 and the Teaching Roundtable is to develop a database based on Labs21 projects and others participating in the Labs21 program. This will provide a frame of reference for future design. Another possibility is to look at the impact of operational procedures on curriculum; for example, downsizing teaching labs to increase efficiency (microscale pendulum). Finally, we must educate users on how to conduct themselves while using the lab. “You can teach an old researcher new tricks.”

Issue #4. Monitoring

An essential component of sustainable operations and maintenance is a baseline of data from which to document improved performance. Comparison of "green buildings" to conventional structures can only be scientifically valid data if benchmarks are identified by the design team. Monitoring of building systems over the long term provides numerous opportunities for analysis, continued improvement in operations, and sustainable maintenance at peak performance levels.

Monitoring can provide facilities managers with real-time data that is useful in rapid response or circumventing problems as they arise. Product and systems designers and manufacturers can have an unprecedented feedback loop on actual operations in real time. In addition, some institutions are exploring the concept of the laboratory building itself as a tool for education about engineering and resource conservation. For example, energy use is perhaps the most obvious metric that can inform students about the environmental impact of buildings. The communication of information about building energy use can take many forms:

- The public display of overall building power use in a manner similar to a stock ticker or time/temperature sign,

- The display of operating information along with the controls for a system like fume hoods,
- Detailed information about the performance of building systems available to students on the Internet.

By their very mission, educational institutions have an obligation to gather information, make available data for research, and contribute to the science of the built environment. Designing and planning systems that will monitor and verify the laboratory's performance are essential tools in the research and education process.

Science projects from all disciplines can draw upon the data gathered and can contribute to the science of the built environment. Displays within the laboratories can be as simple as poster boards or as sophisticated as digital monitor projections. Real time data is valuable to the users, maintenance personnel, researchers around the world, and the laboratory industry itself. Opportunities to partner with organizations that can use real time data can benefit the educational institute and industry.

Whether the audience is a junior high school tour group or the laboratory users themselves, clear messages aimed at behavior change have been effective in a host of demonstration projects. Preliminary research data shows exposed areas of mechanical systems, transparent viewing of laboratory work through "windows on science," or descriptions of biological wastewater treatment systems at work do affect behavior toward the environment beyond a specific encounter.

"Green chemistry," "green buildings," and related environmental programs seem to have broad individual, as well as corporate, impacts.

Case studies have shown that planning to offer tours through an innovative facility carries increased costs, particularly for maintenance and docent-type services. Not planning for tours can be even more costly in terms of ability to answer the inevitable requests with accompanying disruption of lab functions that could have been mitigated with early planning.

Discussion:

Monitoring is an important issue because having data means having the power to change things. Universities typically fight monitoring as much as possible because they do not want the public to know what is being emitted from their labs or how much they spend on these labs.

Future Direction and Next Steps

When designing tools and resources for teaching laboratory design, one must remember that academia cannot be put in a box - there is not one solution for every situation. We must also continue the emphasis on operating procedures and not just theoretical applications.

Possible Resources:

- Peer institutions - comparison with similar universities; learning from their experiences
- Teaching Lab Roundtable Session at future Labs21 conferences
- Creation of an Advisory Board to work with universities and possibly start to gather data to come up with solutions, closure on certain issues.
- Web-based Forum to exchange ideas/data, collaborate on projects, and keep dialogue flowing between conferences.

- Project Kaleidoscope (http://www.pkal.org/): Find out how they see teaching labs changing, and possibly bring them into roundtable discussions.
- Building Envelope (http://www.buildingenvelopes.org/): an online resource providing information on innovative heating, cooling, ventilation and lighting systems to support preliminary design of energy-efficient buildings. Professionals, universities, and research organizations support this effort and provide information for the site.
- Other organizations (i.e., APPA) working on these issues.